When it comes to considering a product's sustainable end of life, there are basically two options: recycling or decomposing. Though the case for biodegradability is rarely brought up in performance fabrics, the situation may change as synthetic fibres engineered to disintegrate in controlled conditions come to market.

Leave no trace

Biodegradability is a feature of responsible design that is rarely put forward in relation to natural fibres, with the notable exception of wool, and that tends not to be emphasised when speaking of manmade materials, with the possible exception of semi-synthetic cellulosic fibres. This may mostly be because a product's end of life is not – yet – considered a key issue. There are however signs that this outlook may be changing both at an industry level, with mounting evidence of microplastic pollution in waterways, and at consumer level, with the phasing out of non-biodegradable plastic bags by retailers. Growing awareness may gradually draw more attention to the need to make and buy clothing that will ultimately disappear.

Uncharacteristically, the news on the floor of the Interfilière show in Paris in January was the launch of fabrics made in Amni Eco Soul, a new biodegradable nylon yarn produced by Italian polyamide specialist Fulgar, seen in the collections of Maglificio Ripa and Sofileta. Fulgar has been building up its sustainable fibre portfolio for the past three years. Its offering includes Q-Nova, a recycled polyamide made from pre-consumer waste, and Evo, a bio-sourced polyamide 10.10 made from castor oil.

In addition to the many performance properties that wool possesses, brands that use the natural fibre, such as Icebreaker, shown here, can promote its ability to biodegrade.

Icebreaker

Amni Soul Eco, its third 'eco-fibre' is an innovative polymer developed by Brazil-based Rhodia, part of the Rhodia-Solvay Group, for which Fulgar is the official European supplier. "Amni Soul Eco has the same properties as a conventional polyamide 6.6; it is easy to care for and comfortable to wear. It is also a drop-in technology using the same weaving, dyeing and finishing processes as conventional polyamide. The only difference is in its end-of-life," says marketing manager, Alan Garosi. With its main plant located in Castel Goffredo, Fulgar is a supplier to the local hosiery industry. This is a product category that the biodegradable nylon yarn would be aptly suited for, tights and stockings being items of clothing that have a limited lifespan. Its biodegradability, in anaerobic conditions, which implies industrial facilities, will however take three years.

Italian knitter Maglificio Ripa has used Fulgar's Amni Soul Eco yarn to make a mesh fabric and jersey knits in various weights. These were developed for "a major Italian sportswear brand" that specifically requested a biodegradable fabric, says sales manager, Fabio Cescon. "Our goal is to reduce our environmental impact at all levels, we have signed Greenpeace's Detox pledge, and are always looking to do better. Biodegradability, along with other sustainable solutions such as bio-sourced or recycled fibres, is an additional option for our clients looking to do the same," he says.

French weaver Sofileta has put together a series of innovative 'lighter-footprint' products under the name Green'oblige for 2017. The range covers four different environment-friendly options: biosourced materials, recycled yarns, recyclable textiles and biodegradable fabrics made in Amni Soul Eco. "This fibre will biodegrade faster in certain conditions compared to a conventional polyamide yarn," Dominique Heuillard, R&D manager, told *WSA*.

Italian knitter Pontetorto won a Performance Days Eco-Award last November for its Eco Hybrid soft shell made in a blend of merino wool, for warmth, and a biodegradable polyamide 6.6, which provides moisture management.

An expanded offering

In fitness wear and hosiery, a biodegradable stretch yarn made by Japanese fibre producer Asahi Kasei would be an ideal match for Fulgar's biodegradable nylon. In development for three years, this new stretch yarn is part of the Roica EcoSmart range. It will disintegrate by 90% in six months, leaving no harmful substances in nature, as certified by Hohenstein Institute in Germany. "This yarn has the same stretch and recovery properties and durability as our other stretch fibres," says Uwe Schmidt, general manager for Asahi Kasei Europe. "It is the same polymer as our conventional Roica stretch yarns, but one of its raw materials is different, a polyurethane-ester replaces the polyurethane-ether diol." The fibre will disintegrate only in a specific biological environment. Above and beyond the notion of biodegradability, a term Mr Schmidt is not keen on, he underlines the fact that the fibre will have no harmful impact on soil once it has decomposed.

Hohenstein Institute

Biodegradability 101

To begin, it is not recommended to leave any clothing or textiles in nature, nor is it necessarily a good idea to place used apparel in a home composter, even if made in materials that are said to biodegrade. The notion of biodegradability is not a simple one, as there are different conditions in which materials will disintegrate. Each material will behave differently and take less or more time to disappear. The two main forms of biodegradability are aerobic or anaerobic, depending on whether the microorganisms and fungi that digest waste operate with or without oxygen.

Aerobic decomposition occurs when a waste product is buried in soil and composted. Natural and cellulosic fibres could degrade in those conditions. The time it takes for them to break down will vary on fibre composition, fabric construction and chemical finishing (from dyeing to coating). When the process runs smoothly, it produces a combination of carbon dioxide, methane and biomass which can be used as compost.

Anaerobic biodegradability implies higher temperatures and applies to industrial facilities, such as solid waste treatment plants or municipal waste management operations. It decomposes plastics and is used to produce biogas. Rhodia's Amni Soul Eco will disappear in an anaerobic digester in three years. This is according to US standard ASTM D 551 which applies to plastics. The norm further stipulates that the result be given in a percentage of material that disappears in a given time.

There is no standard test for biodegradability in textiles but a few certification organisations have developed protocols applicable to clothing, namely Vinçotte, in Belgium, and the Hohenstein Institute, in Germany. The latter has chosen to focus on aerobic biodegradability, which it deems a more "realistic" norm compared to anaerobic processes. The test setup was developed in accordance with different EU standards like the norm 13432 for bioplastics. Hohenstein recommends testing the ecotoxicological profile of the soil after biodegradation to ensure that it can be reused. "This test provides information on the environmental impact of water-soluble pollutants potentially present in the test soil," says Christin Glöckner at the Hohenstein Institute.

The first brand to develop biodegradable lingerie and tights, Wolford chose to use a blend of Lenzing Modal, Lauffenmühle Infinito and Roica EcoSmart, which are biodegradable and certified cradle-to-cradle by EPEA Switzerland.

Wolford

Austria-based Wolford is the first brand to use the Roica yarn in a commercial range, officially presented at Texworld in February. The Austrian intimate apparel and hosiery manufacturer is introducing a lingerie set and tights made in a blend of Lenzing Modal, Lauffenmühle Infinito and Roica EcoSmart, which will biodegradable and are certified cradle-to-cradle by EPEA Switzerland.

The cellulosic fibres produced by Austrian fibre producer Lenzing, namely viscose, modal and lyocell, are derived from wood pulp and considered compostable, as certified by Belgian lab Vinçotte. Asahi Kasei's Cupro, is also a cellulosic fibre, though it is made from cotton linters, and will decompose in two months, as tested by Innovhub, an innovation lab network linked to the Milan Chamber of Commerce. The innovative cellulosic yarn Umorfil Beauty fibre, a viscose enhanced with collagen, developed by Taiwan-based Camangi has also been tested for biodegradability. Its score of 120% means it degrades faster than the norm, says Camangi marketing manager, Janis Lee.

To make its biodegradable Infinito fibre, Lauffenmühle has combined Lenzing Tencel with "a modified oil-based polymer". It promotes this blend as an alternative to poly-cotton fabrics used to make workwear. The German yarn and textile manufacturer has obtained cradle-to-cradle certification that its raw materials and chemicals are safe for biological cycles. In addition to the textiles it makes under the Reworx brand, it also offers compostable accessories including sewing thread, tapes, fasteners and interlinings.

The array of components that biodegrade is also expanding thanks to Freudenberg's interlinings, made in viscose, which the company says will decompose in aerobic conditions in six weeks and in an anaerobic digester in 12 weeks. When composted, they are said to disintegrate in four weeks.

Recently developed fibres, whether manmade or natural, are also considered eligible for composting or biodegrading. Materials made in Qmilk, a casein fibre containing only natural ingredients, have been composted by company founder, Anke Domaske, who says they disintegrate in six weeks. Biosteel, a newly launched silk protein fibre by German start-up AMSilk, which adidas is using to make shoe uppers, has obtained certification for biodegradability from the SGS Fresenius Institute. According to OECD Norm 301 B, the silk material was found to be "readily biodegradable," the best possible test result the company says. Swedish trimmings maker Rudholm & Haak presented its first range of compostable buttons and closures at ISPO this year. Kapok specialist Flocus says its fibre is compostable, though it has not yet been tested for this.

Part of a broader picture

Environmental issues are part of a broad mega-trend that touches on all aspects of modern life. Mr Schmidt, at Asahi Kasei, says: "Consumers hear about issues related to microplastics in oceans and water pollution; they are beginning

Made from milk that is unsuitable for consumption, Qmilk casein fibre is biodegradable and recyclable. The first materials developed are nonwovens, and the company plans to introduce its first yarns for weaving and knitting later this year.

Qmilch GmbH

to understand that what they buy has an impact on the planet and are beginning to modify their habits. As an industry, it is our responsibility to address all issues pertaining to sustainability."

Biodegradability may not yet be at the forefront of the mind of consumers, but Ms Domaske believes it is important at industry level. "Compostability is part of the larger sustainable story, but it may be better from an environmental point of view to reuse or recycle a product to compensate for the energy required for its manufacturing." Qmilk, she points out, can be melted and spun again and is therefore recyclable.

In discussions with brands for the past five years, Mr Garosi, at Fulgar says biodegradability is "an issue that they take seriously". The company intends to focus on Amni Soul Eco throughout 2017 to test market and consumer acceptance.

To biodegrade or to recycle?

The decision to favour recycling or decomposing when developing sustainable clothing remains up for debate. "More than biodegradability, the question my customers ask more often, is whether the fibre is recyclable," says Flocus CEO, Jeroen Muijsers. "Kapok is both recyclable and compostable; in some cases, its disintegration in nature may be a way to avoid extra pollution."

The issue has come up, admits Woody Blackford, Columbia Sportswear's vice president of R&D, but he says few synthetic polymers do biodegrade and when two different polymers are combined, as they are in waterproof-breathable laminates, it is a challenge. "Some materials might decompose, but they might take many years, or even a century to do so," he says.

Taking into consideration a product's entire lifecycle means that one must not only focus on the complete item of clothing but also on the many parts it is made from, says Anna Rodewald, a partner at GreenRoomVoice, an independent organisation communicating about sustainability in the outdoor and boardsports community. "The Cradle to Cradle approach helps [companies] take decisions on material choices and differentiates two cycles: the biological and the technical material loop," she says. These must be kept separate, to avoid contamination in nature. The chemicals used (dyestuffs, finishing) will impact a material's ability to degrade. A cotton garment will decompose, but it might contain a silicon print or a chemical finish that does not and may be harmful for the environment." In some cases, she believes it might be better to choose a material that is inert and will not degrade at all. It will then be easier to identify it, remove it and dispose of it as it should be. A pure PTFE membrane would be an example of such a material, while other types of membranes may fragment into millions of microparticles.

Umorfil Beauty fibre is now available in a polyester yarn (shown in the spacer fabric) that has a natural golden champagne colour. The viscose version of the collagen peptide-enhanced yarn biodegrades in aerobic conditions by 120% according to ISO: 14855-1:2012.

Camangi Corp.

"The main challenge today is the lack of infrastructure for the different end-of-life options," says Ms Rodewald, taking compostable plastic bags made from corn-starch as an example. "When these end up in an industrial composting facility, they are mixed with biological waste that is expected to degrade within three months, but the bags will take six months or more. What seems in theory a good strategy ends up being useless. Not only do the bags take too long to biodegrade, they also resemble plastic bags made from crude oil."

One point raised by Arnaud Tandonnet, global sustainability director for Invista's apparel division, is that composting facilities should be located close to where the products are disposed of to reduce the carbon footprint of the process. "Biodegradability is an issue we are looking into and working on. We are weighing up the different end-of-life options that could be available to us," he says. One technique that is viewed as a possible option is the gasification of waste by plasma that could be an alternative to landfilling.

Closer to home, the everyday wearing and washing of clothing occasions a certain form of gradation. Conventional elastanes do not stand up well in chlorine. Producers of the stretch fibre have developed versions that will last longer no matter how consumers (mis)treat their swimwear.

Conversely, one cannot fail to observe the existence of a thriving market for pre-degraded clothes, otherwise known as distressed jeans. This long-lasting fashion trend squarely opposes the sportswear industry's usual focus on durability. Though the development of biodegradable performance materials remains quite challenging, it echoes a notion often promoted by the outdoor industry: leave no trace.